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BUFFALO
AIR POLLUTANT EMISSION INVENTORY

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service

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The results of an emission inventory of air pollutant sources in the Buffalo, New York Metropolitan Area is presented. The objectives of this study were to determine the total quantities of the various air pollutants emitted and to estimate their seasonal and geographical variation. The study area was divided into a grid coordinate system, and the emission quantities were reported in terms of tons of pollutant per grid for a summer, winter, and average day. The pollutants considered in this survey were sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides. The source categories considered were fuel combustion in stationery sources, transportation, industrial processes, and solid waste disposal.

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PUBLIC HEALTH SERVICE
Consumer Protection and Enviromental Health Service
National Air Pollution Control Administration
Division of Air Quality and Emission Data
Durham, North Carolina
December, 1968

LIST OF TABLES

		Page
Table 1	Population Characteristics in the Buffalo Study Area	9
Table 2	Summary of Emissions in the Buffalo Study Area	14
Table 3	Fuel Use in the Buffalo Study Area	17
Table 4	Fuel Characteristics in the Buffalo Study Area	18
Table 5	Method of Heating in Dwelling Units in the Buffalo Study Area	19
Table 6	Emissions from Fuel Combustion in Stationary Sources in the Buffalo Study Area	20
Table 7	Vehicle Miles Traveled and Motor Fuel Consumed in the Buffalo Study Area	24
Table 8	Aircraft Activity	25
Table 9	Railroad Diesel Fuel Use in the Buffalo Study Area	26
Table 10	Fuel Use by Vessels in the Buffalo Study Area	26
Table 11	Emissions from Transportation in the Buffalo Study Area	27
Table 12	Emissions from Industrial Processes in the Buffalo Study Area	30
Table 13	Emission from the Chemical Industry of Niagara County	31
Table 14	Solid Waste Disposal in the Buffalo Study Area	34
Table 15	Emissions from Solid Waste Disposal in the Buffalo Study Area	35
Table 16	Emissions by Grid for the Buffalo Study Area	37

TABLE OF CONTENTS

ACKNOWLEDGMENTS.....5
INTRODUCTION.....6
STUDY AREA.....7
GRID-COORDINATE SYSTEM.....11
RESULTS.....13
Summary of Emissions.....13
Fuel Combustion in Stationary Sources.....16
Transportation.....23
Industrial Process Losses.....29
Solid Waste Disposal.....33
EMISSIONS BY GRIDS.....36
REFERENCES.....46
APPENDIX.....48

LIST OF FIGURES

		Page
Figure 1	Location of Study Area	8
Figure 2	Population Density Map of Study Area	10
Figure 3	Grid System for Study Area	12
Figure 4	Location of Major Emission Sources in the Study Area	15
Figure 5	Sulfur Oxides Emission Density for Average Day	41
Figure 6	Particulate Emission Density for Average Day	42
Figure 7	Carbon Monoxide Emission Density for Average Day	43
Figure 8	Hydrocarbons Emission Density for Average Day	44
Figure 9	Nitrogen Oxide Emission Density for Average Day	45

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INTRODUCTION

This report presents the results of an emission inventory of air pollutant sources in the Buffalo Metroplitan Area. A modified version of the Rapid Survey Technique[1] was employed in the survey. The objectives of this study were to determine the total quantities of the various air pollutants emitted and to estimate their seasonal and geographical variation. To accomplish this task, the study area was divided into a grid coordinate system, and the emission quantities were reported in terms of tons of pollutant per grid for a summer, winter, and average day.

The pollutants considered in this survey were sulfur oxides, particulates, carbon monoxide, hydrocarbons, and nitrogen oxides. Data presented herein should be representative, for the most part, of 1967 and were mainly gathered by the acknowledged local agencies. All major sources categories except solvent evaporation were included in the survey. The source categories considered were fuel combustion in stationery sources, transportation, industrial processes, and solid waste disposal.

STUDY AREA

For purposes of this survey, the Buffalo Standard Metropolitan Statistical Area (SMSA) was selected as the study area. It consists of two counties-Erie and Niagara-and covers an area of 1567 square miles (Figure 1). Although the Buffalo SMSA is adjacent to the Rochester SMSA, they are in fact two distinct urban areas seperated by over 50 miles of non-urbanized land. This is also the case southwest of the Buffalo SMSA where Erie, Pennsylvania is located some 80 miles away. It is important to note that industrial zones are however located on the Canadian side of the Niagara River. As shown in Table 1, the present population of the study area is 1,320,000 which is only a 1 per cent increase over 1960.[2,3] Population density ranges from about 50 inhabitants per square mile in the northwest corner of Niagara county to over 12,000 for the City of Buffalo. This is illustrated in Figure 2, where 1960 population distribution by political jurisdiction is shown.[4]

The climate of the area is affected by topography. Both lakes are bordered by plains. The temperature of the lands adjacent to the lakes is tempered by the presence of the warm lakes in the winter and the cool lakes in the summer. The prevailing winds are from the southwest off of Lake Erie.

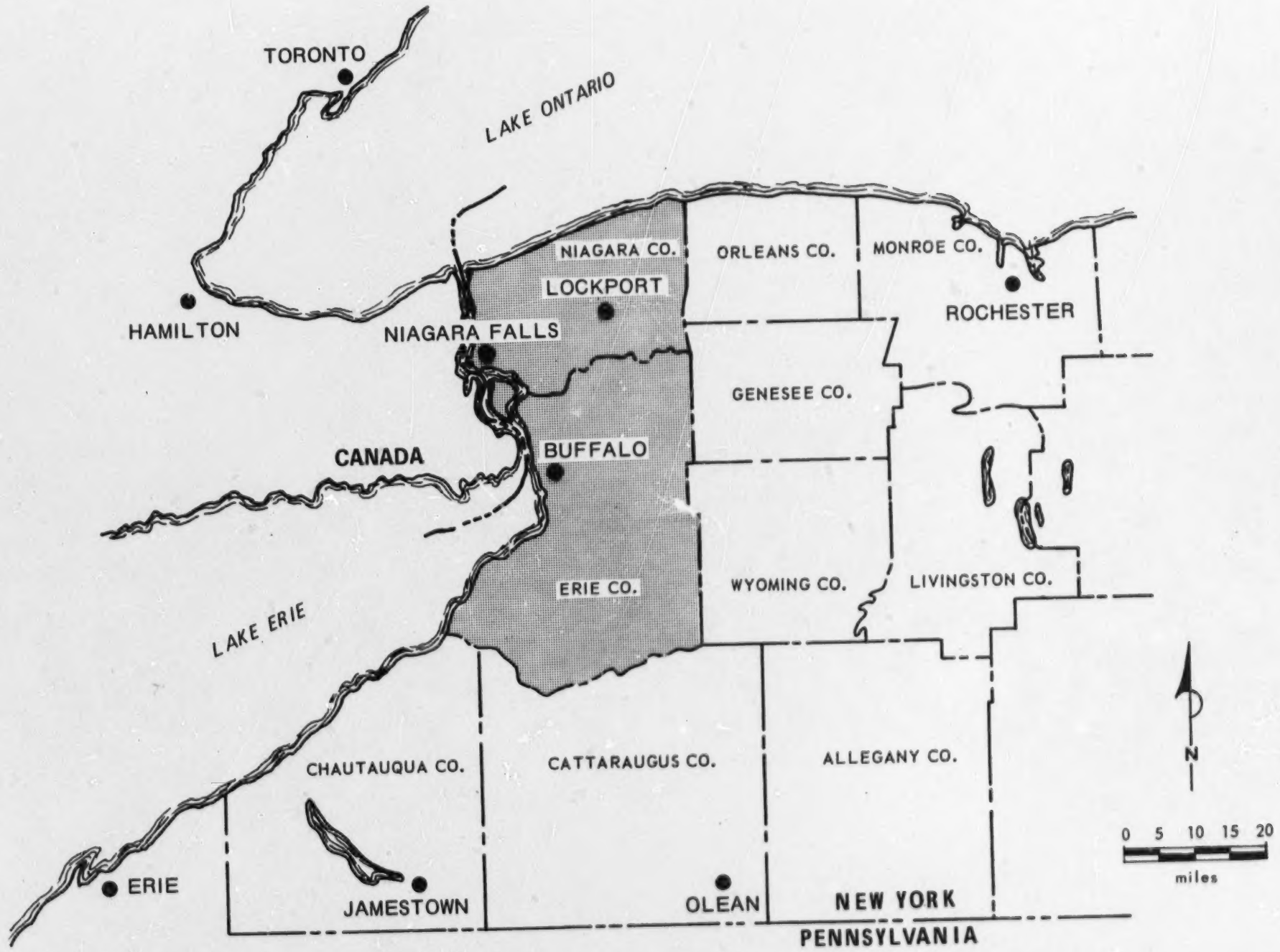

Figure 1. Location of study area.

Table 1 Population Characteristics
in the Buffalo Study Area

Jurisdiction	1960 Population	Present Population*	Percent Increase
Erie County			
Buffalo	532,759	481,453	-9.6
Lackawanna	29,564	28,717	-2.9
Tonawanda	21,561	21,946	+1.8
Remainder of county	480,804	554,229	+13.2
County Total	1,064,686	1,086,345	+2.0
Niagara County			
Lockport	26,443	25,616	-2.1
Niagara Falls	102,394	88,286	-13.8
North Tonawanda	34,757	35,994	+0.1
Remainder of county	78,675	84,581	+7.5
County Total	242,269	234,477	-3.2
Study Area	1,306,955	1,320,722	+1.1

* 1966 for Erie County - Source: New York State Population Changes[2]
* 1967 for Niagara County - Source: New York State Population Changes[3]

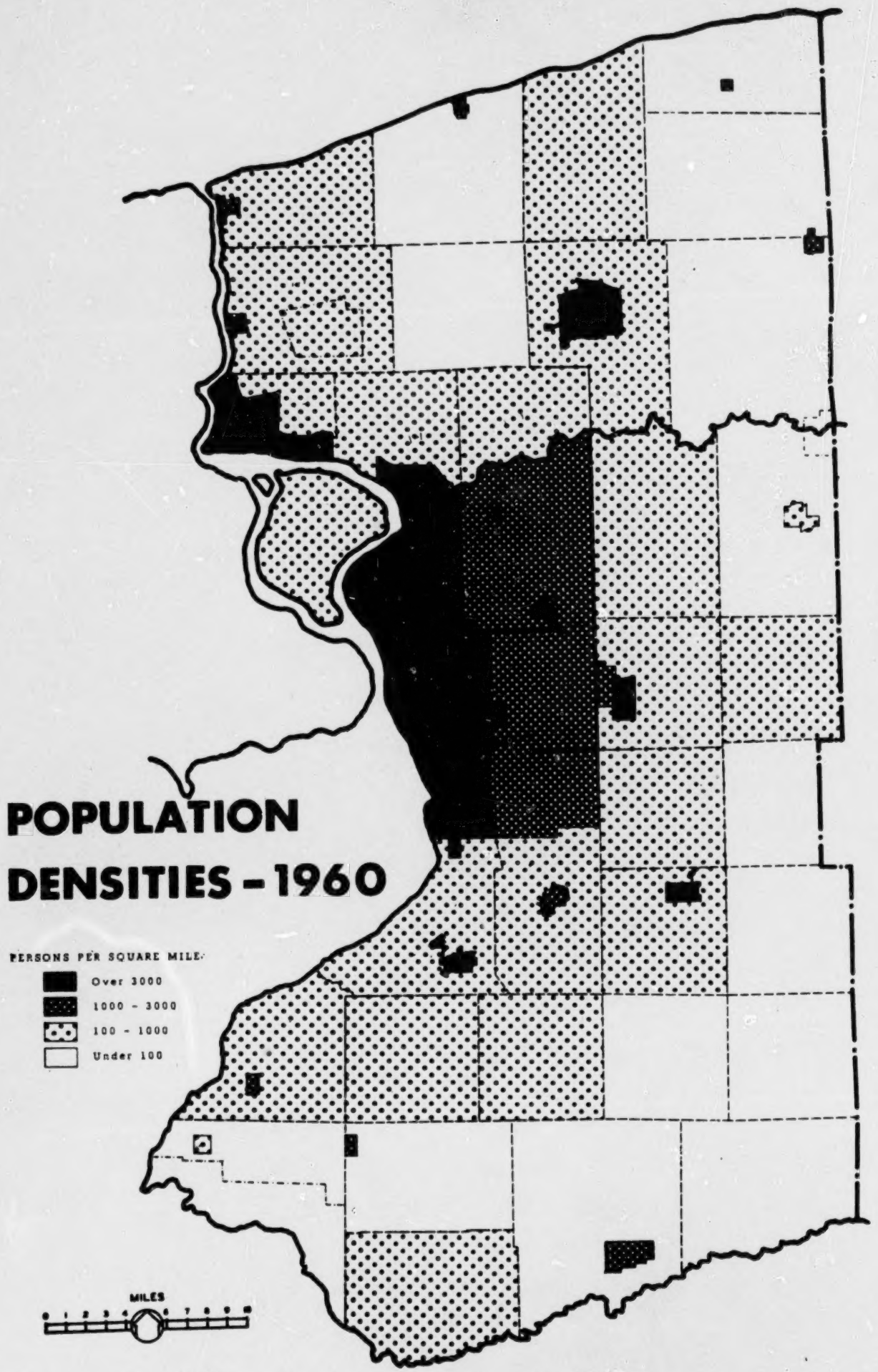

Figure 2 Population Density Map of Study Area

GRID-COORDINATE SYSTEM

Grid coordinates based on the Universal Transverse Mercator system were used in this study to show geographical distribution of sources and emission. As shown in Figure 3, the study area was divided into 46 grids of three different sizes-25 sq. km., 100 sq. km., and 400 sq. km.

Different sized grids are used to limit the number of grid zones and yet allow a satisfactory definition of geographical gradation of emission in areas where majority of pollution occurs. For this reason, the 25 sq. km. grids are used in the downtown areas, where density of emissions may change abruptly within short distances. In areas primarily rural in nature the use of small zones is not as important.

As illustrated in Figure 3, each grid line is identified by a coordinate number. The north-south and east-west coordinates are expressed in ten thousand meters. The point sources are identified by both X and Y coordinates to the nearest 100 meters. The grids are identified by the geographical center of the grid zone.

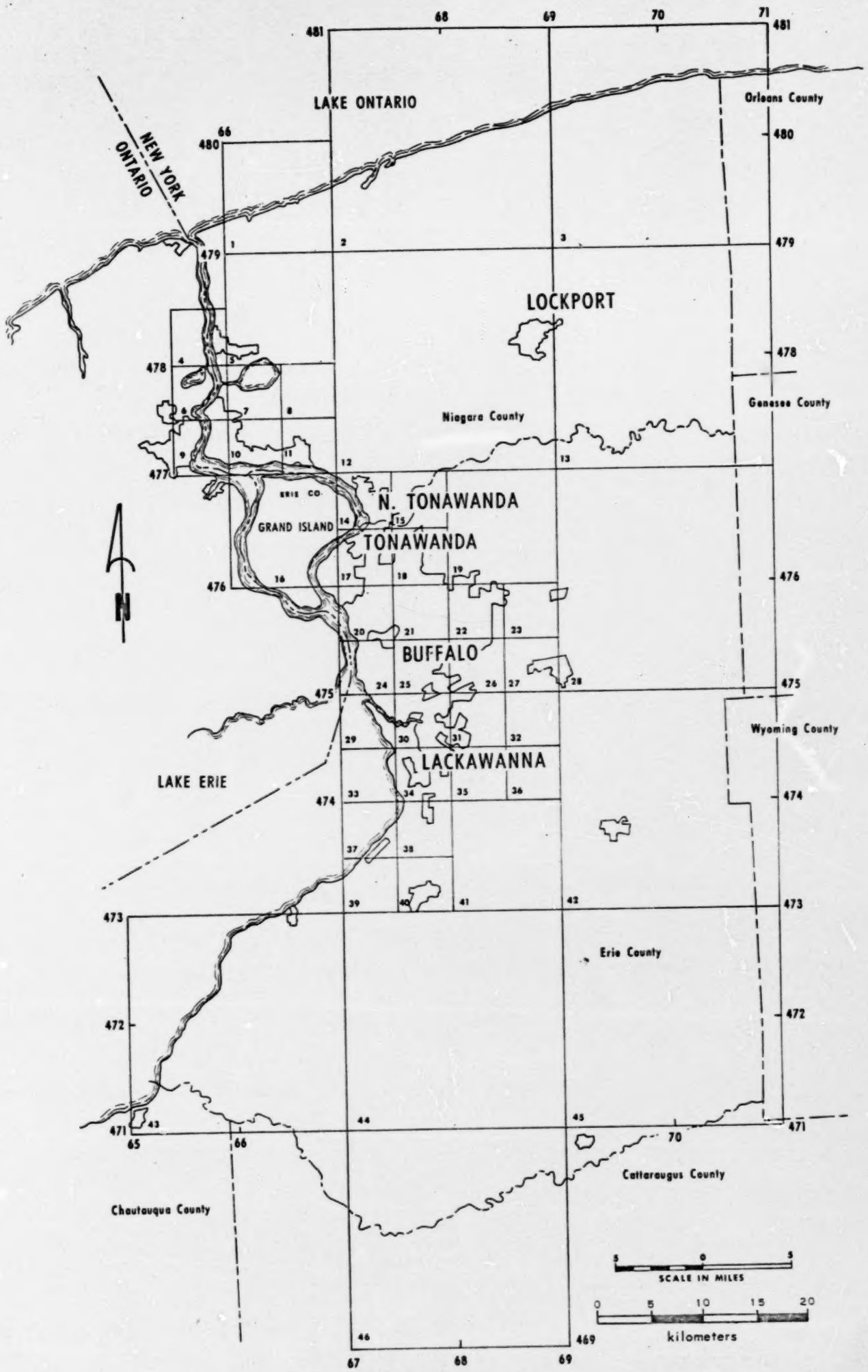

Figure 3. Grid system for study area.

RESULTS

Summary of Emissions

The emissions for the two counties are summarized in Table 2, Fuel combustion accounted for 90 per cent of the sulfur oxides, 59 per cent of the particulates, and 73 per cent of the nitrogen oxides. Industrial process emissions contribution 8 per cent of the sulfur oxides, 32 per cent of the particulates, and 46 per cent of the the hydrocarbons. Transportation accounted for 94 per cent of the carbon monoxide, 48 per cent of the hydrocarbons, and 25 per cent of the nitrogen oxides. Solid waste disposal accounted for less than 2 per cent of the particulate emissions.

A total of 21 establishments were considered as point sources. These include all the major sources of pollution for which the necessary data was available. The location of these and eight municipal incinevators are shown in Figure 4.

Table 2 Summary of Emissions in the Buffalo Study Area

Source	Area	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Fuel Combustion	Erie	330,000	76,000	8,000	2,600	82,000
	Niagara	42,000	7,400	1,400	530	13,000
	Total	370,000	83,000	9,400	3,100	95,000
Process Emissions	Erie	28,000	26,000	10,000	~~60,000~~ 21,000	1,000
	Niagara	7,900	19,000	6,300	2,400	100
	Total	36,000	45,000	16,000	~~62,000~~ 23,400	1,000
Transportation	Erie	4,000	6,000	360,000	52,000	25,000
	Niagara	500	1,000	82,000	12,000	5,000
	Total	4,500	7,000	440,000	64,000	30,000
Solid Wastes	Erie	230	2,000	380	50	260
	Niagara	65	580	330	17	90
	Total	300	2,600	710	67	350
Total	Erie	360,000	110,000	380,000	~~110,000~~ 78,000	110,000
	Niagara	50,000	28,000	90,000	15,000	19,000
	Total	410,000	140,000	470,000	~~130,000~~ 93,000	130,000

Note that all numbers are presented to only two significant digits

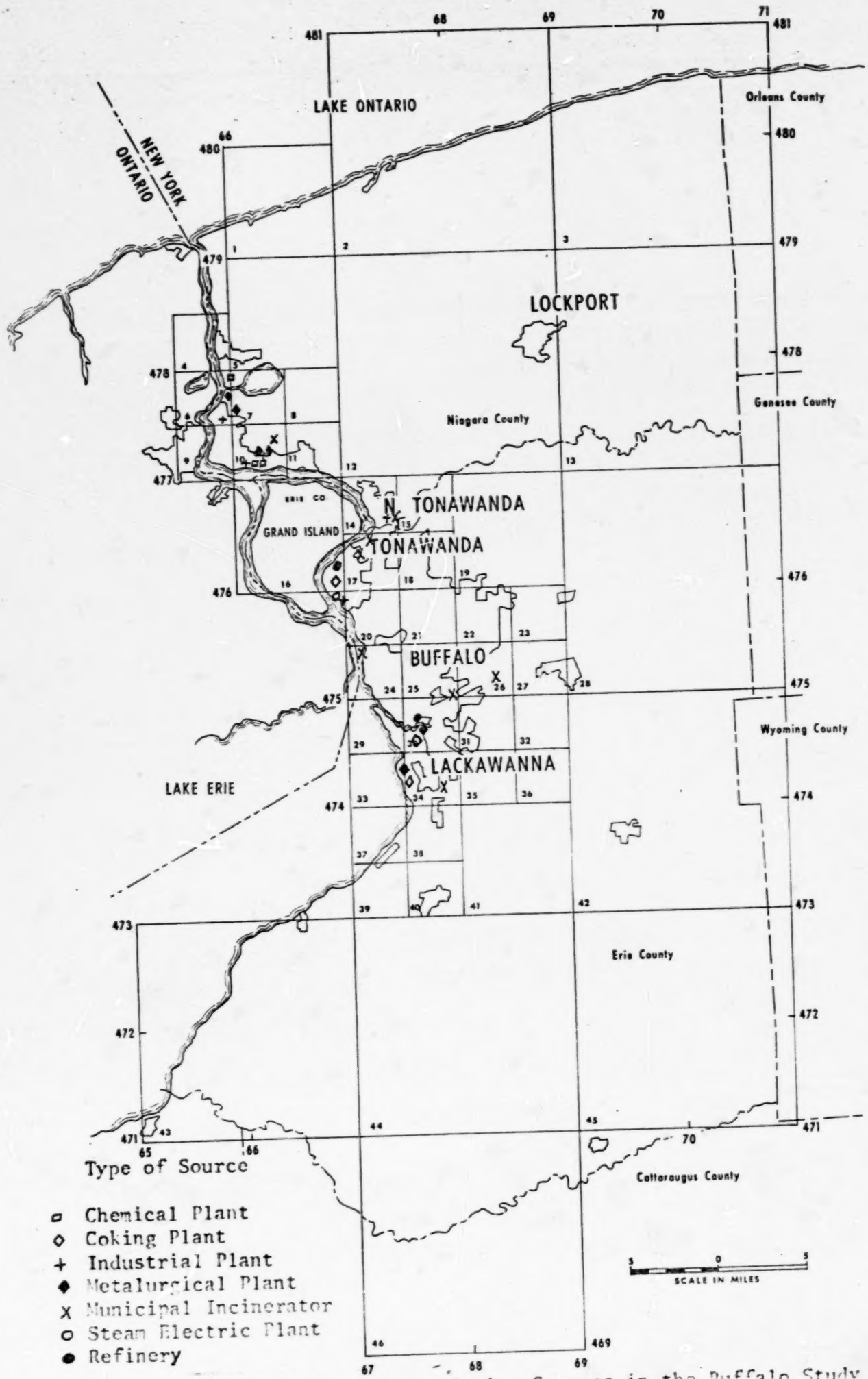

Figure 4 Location of Major Emission Sources in the Buffalo Study Area

Fuel Combustion in Stationary Sources

As shown in Table 3, approximately 13 million tons of coal and coke, 170 million gallons of residual fuel oil, 190 million gallons of distillate fuel oil and 110 billion cubic feet of natural gas were consumed during 1967 in the Buffalo Study Area. In terms of the total energy supplied (512 x 10^6 BTU's), coal and coke was the primary fuel accounting for about 67 per cent. The average chemical characteristics of the fuels are summarized in Table 4.

The industries in the area are the largest consumers of fuel. During 1967, they consumed more than 88 per cent of the coal, over 93 per cent of the residual fuel oil and approximately 26 per cent of the natural gas burned in the area. Most of the industrial fuel use is concentrated in the twenty industrial point sources. More than 60 per cent of coal, residual fuel oil and distillate respectively were burned in these large plants. In addition, 1.5 million tons of coal was consumed by the local utility for the generation of electricity.

Natural gas is the primary fuel used for domestic space heating. As shown in Table 5, about 83 per cent of all dwelling units are presently heated by natural gas. The remainder of dwelling units are essentially supplied by distillate fuel oil with the use of coal being almost non-existant.

Distillate and residual fuel oil and natural gas are being used by the multitude of commerical and institutional establishments in the area. Approximately 52 million gallons of distillate fuel oil and 14 billion cubic feet of natural gas were used in these establishments.

The emissions of air pollutants from the burning of fuels are summarized in Table 6. The burning of coal is by far the primary source of all pollutants, emitting more than 90 per cent of oxides of sulfur, particulates, and carbon monoxide and about 80 per cent of hydrocarbons and oxides of nitrogen.

The information on consumption of fuels presented herein was obtained from a diverse number of data sources. An appraisal of sources made during the period 1959 and 1962 by the State of New York Air

Table 3 Fuel Combustion in the Buffalo Study Area for 1967

Type	Area	Residential	Industrial	Other	Total	BTU's x10^{12}
Coal & Coke (1000 tons/yr)	Erie	21	11,500	8	11,500	300
	Niagara	4	1,700	1	1,700	44
	Total	25	13,200	9	13,200	340
Residual Fuel Oil (1000 gal/yr)	Erie	neg	87,000	17,000	100,000	15
	Niagara	neg	68,000	2,000	70,000	10
	Total	neg	160,000	19,000	170,000	25
Distillate Fuel Oil (1000 gal/yr)	Erie	40,000	41,000	52,000	130,000	19
	Niagara	44,000	13,000	neg	57,000	8
	Total	84,000	54,000	52,000	190,000	27
Gas (10^6 ft ^{3}/Yr)	Erie	58,000	23,000	12,000	94,000	94
	Niagara	6,000	6,000	2,200	15,000	15
	Total	65,000	29,000	14,000	110,000	110
BTU's x10^{12}	Erie	65	340	23	430	
	Niagara	13	62	3	78	
	Total	78	380	26	510	

neg-negligible

Note that all numbers are presented to only two significant digits.

Table 4 Average Fuel Characteristics
in the Buffalo Study Area

F U E L	Percent Sulfur	Percent Ash
Coal	1.8	8.1
Distillute fuel oil	0.24	neg
Residual fuel oil	2.4	neg
Natural gas	0.0008	neg

neg-negligible

Table 5 Method of Heating in Dwelling Units
in the Buffalo Study Area

A R E A	All occupied units	Coal	Oil	Gas
Erie County	317,000	2,300	30,000	285,000
Niagara	67,000	700	33,000	33,000
Total Study Area	384,000	3,000	63,000	318,000

Table 6 Emissions from Fuel Combustion in Stationary Sources in the Buffalo Study Area (tons/yr)

FUEL & USE	Area	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-Carbons	Nitrogen Oxides
COAL						
Industrial	Erie	220,000	66,000	6,600	2,000	48,000
	Niagara	33,000	6,100	1,100	360	7,200
	Total	250,000	72,000	7,700	2,400	55,000
Residential	Erie	240	580	520	100	80
	Niagara	40	100	90	20	15
	Total	280	680	610	120	95
Steam Electric	Erie	81,000	5,100	400	160	16,000
	Niagara	no plants				
	Total	81,000	5,100	400	160	16,000
Other	Erie	94	230	210	41	33
	Niagara	8	20	20	4	3
	Total	100	250	230	45	36
Total Coal	Erie	300,000	72,000	7,700	2,300	64,000
	Niagara	33,000	6,200	1,200	380	7,200
	Total	330,000	78,000	8,000	2,700	71,000
RESIDUAL FUEL OIL						
Industrial	Erie	15,000	950	86	86	3,100
	Niagara	7,600	790	70	70	2,500
	Total	23,000	1,700	160	160	5,600
Other	Erie	3,200	190	17	17	610
	Niagara	500	30	2	2	90
	Total	3,700	220	19	19	700
Total Residual	Erie	18,000	1,200	100	100	3,700
	Niagara	8,100	820	72	72	2,600
	Total	26,000	2,000	170	170	6,300
DISTILLATE FUEL OIL						
Industrial	Erie	2,200	420	40	40	1,500
	Niagara	370	100	10	10	460
	Total	2,600	520	50	50	2,000
Residential	Erie	770	160	40	60	240
	Niagara	850	180	44	66	270
	Total	1,600	340	84	130	510
Other	Erie	1,000	210	52	80	310
	Niagara	neg	neg	neg	neg	neg
	Total	1,000	210	52	80	310

Table 6 Emissions from Fuel Combustion in Stationary Sources in the Buffalo Study Area (tons/yr) (con't)

FUEL & USE	a	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Total Distillate	Erie	4,000	800	130	180	2,000
	Niagara	1,200	280	54	76	730
	Total	5,200	1,100	180	260	2,700
GAS						
Industrial	Erie	5	1,000	5	neg	8,600
	Niagara	1	50	1	neg	640
	Total	6	1,100	6	neg	9,200
Residential	Erie	11	540	11	neg	3,300
	Niagara	1	60	1	neg	380
	Total	12	600	12	neg	3,700
Other	Erie	3	120	3	neg	760
	Niagara	1	20	1	neg	120
	Total	4	140	4	neg	880
Total Gas	Erie	19	1,700	19	neg	13,000
	Niagara	3	130	3	neg	1,100
	Total	22	1,800	22	neg	14,000
ALL FUELS						
Industrial	Erie	240,000	68,000	6,700	2,100	61,000
	Niagara	41,000	7,000	1,200	440	11,000
	Total	280,000	75,000	7,900	2,500	72,000
Residential	Erie	1,000	1,300	570	160	3,600
	Niagara	890	340	140	86	660
	Total	1,900	1,600	710	250	4,300
Steam Electric	Erie	81,000	5,100	400	160	16,000
	Niagara	n o p l a n t s				
	Total	81,000	5,100	400	160	16,000
Other	Erie	4,300	750	280	140	1,700
	Niagara	500	70	23	6	1,200
	Total	4,800	820	300	150	2,000
Total	Erie	330,000	76,000	8,000	2,600	82,000
	Niagara	42,000	7,400	1,400	530	13,000
	Total	370,000	83,000	9,400	3,100	95,000

neg-negligible

Note that all numbers are presented to only two significant digits

Pollution Control Board. [4,5] When more recent data was not available, the estimates presented in these reports were updated and used in this survey. This was the case for obtaining total consumption rates of fuel oils as well as all fuels in the commerical-consumption category. Coal and natural gas consumption data by county and consumer category were obtained from the National Coal Association and Iroquois Gas Company, respectively. The domestic consumption of all fuel was calculated on basis of degree days and Census of Housing data using the method presented in the Rapid Survey Technique[1]. Information on fuel use by the point sources was obtained from each of the local agencies. These data had been previously gathered from each plant by questionaire.

Transportation

Four different classes of sources were considered under this category. These consisted of (1) motor vehicles, (2) aircraft, (3) railroads and (4) vessels. Vehicles mile and gasoline-diesel fuel consumtion data which were used to calculate the emissions from motor vehicles are summarized in Table 7. Approximately 15.4 million vehicles miles per day are travelled within the Study Area resulting in the annual consumption of 371 million gallons of gasoline and 54 million gallons of diesel fuel.

Aircraft activity in terms of the number of operations at the two major airports-Buffalo International and the Niagara Falls International Airport-are summarized in Table 8A and 8B. A total of some 167,000 itinerant operations and 125,000 local operations took place during 1967. An itinerant operation is one that either originates or ends at the airport whereas a local operation is one that both originates and ends at the same airport. The consumption of fuels by railroads and vessels is summarized in Table 9 and 10, respectively. About 12.6 million gallons of diesel fuel, 1.8 million gallons of residual fuel oil and 40 thousand tons of coal were used for these purposes.

The emissions from transportation sources are listed in Table 11. Motor vehicles are by far the major source of air pollutants in this category. In 1967, they accounted for 98 per cent of carbon monoxide, 97 per cent hydrocarbons, 93 percent of oxides of nitrogen, 74 per cent of particulate matter and 60 per cent of sulfur oxides emitted from all transportation sources. Vessels were an important source of oxides of sulfur accounting for some 33 per cent of the total for this category.

The motor vehicle data was based in part on a 1962 report.[6] This report presented vehicle mile data by zones for travel on primary roads. These data were expanded to include travel on seconary roads and updated to 1967 on the basis of gasoline sales. Emission factors based on an average speed of 25 miles per hour were used.

The information on aircraft was obtained from an FAA report [7] and information supplied by the local air traffic controllers. The emissions are for all activity under 3500 feet.

Table 7 Vehicle Miles Traveled and Motor Fuel Consumed in the Buffalo Study Area

T Y P E	Vehicle miles per day	Fuel use gal. per year
Gasoline Powered	14,650,000	371,000,000
Diesel Powered	750,000	54,000,000
Total	15,400,000	425,000,000

Table 8A Aircraft Activity at the Buffalo International Airport

T Y P E	Itinerant Operations	Local Operations
Air Carrier	74,903	0
General Aviation	43,635	26,438
Military	1,126	1,740
Total	119,664	28,178

Table 8B Aircraft Activity at the Niagara Falls International Airport

T Y P E	Itinerant Operations	Local Operations
Air Carrier	462	0
General Aviation	40,614	77,856
Military	15,973	19,594
Total	57,049	97,450

Source: FAA Air Traffic Activity, 1967.
An operation is a take-off or a landing

Table 9 Railroad Diesel Fuel Use
in the Buffalo Study Area

Erie County	12,000,000 gallons/year
Niagara County	620,000 gallons/year
Total Study Area	12,600,000 gallons/year

Table 10 Fuel Use by Vessels
in the Buffalo Study Area

Coal	39,500 tons/year
Residual Fuel Oil	1,800,000 gallons/year

Table 11 Emissions from Transportation
in the Buffalo Study Area (tons/yr)

Source	Area	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Auto & Trucks	Erie	2,200	4,200	350,000	51,000	23,000
	Niagara	490	950	78,000	11,000	5,200
	Total	2,700	5,200	430,000	62,000	28,000
Aircraft	Erie	neg	310	8,400	370	280
	Niagara	neg	22	4,300	800	200
	Total	neg	330	13,000	1,200	480
Railroads	Erie	240	660	360	820	1,300
	Niagara	10	30	20	40	70
	Total	250	690	380	860	1,400
Vessels	Erie	1,500	820	60	20	460
	Niagara	neg	neg	neg	neg	neg
	Total	1,500	820	60	20	460
Total	Erie	4,000	6,000	360,000	52,000	25,000
	Niagara	500	1,000	82,000	12,000	5,500
	Total	4,500	7,000	440,000	64,000	30,000

neg-negligible

Note that all numbers are presented to only two significant digits

The data for railroads and shipping were taken directly from the previous reports.[4,5] It was assumed that there had been no significant change in either activity since 1959 to 1962.

Industrial Process Losses

In all, emissions data from some one hundred industrial plants were obtained and are included. In Niagara county the major process sources included three plants in the abrasives field, three firms in the carbon products business, seven chemical plants, one grain mill, nine metals processing firms and ten firms classified as other.

The Erie county data is based on data for one cement mill (from literature), three chemical plants, four grain processers, the two large intergrated steel mills, the three coke plants, two foundries, and the two refineries.

The emissions from process loss sources are presented in Table 12 and 13. The metalurgical industry combined with coke manufacture was the main source of sulfur oxides and particulates. This group of industries accounted for 56 per cent of the sulfur oxides and 89 per cent of the particulates from industrial processes.

Refineries accounted for 23 per cent of the sulfur oxides, 63 per cent of the carbon monoxide, 87 per cent of the hydrocarbons, and 12 per cent of the oxides of nitrogen. Other chemical plants emitted 23 per cent of the sulfur oxides and 37 per cent of the carbon monoxide.

The completeness of the data in this category was variable. As in any emission inventory of industrial processes the results depend on the availability of data and appropiate emissions factors. In Niagara county the emission inventory had been completed so it is felt that the data for Niagara county is complete. The emission inventory in Erie county had only recently been started and only a few of the questionaires had been returned. We had access to about 10 per cent of the questionaires that had been distributed. The officicals of the Niagara County Health Department felt that in the future most of the questionaires would be returned and made available. The size and number of other sources was not known. It was thought that those available included most of the major process sources.

Most of the industrial process data was obtained from emissions inventories conducted by the local agencies. Literature sources were consulted for production data from which emissions could be estimated by the use of average emission factors.[8] Data on the two refineries

Table 12 Emission from Industrial Processes (tons/yr)
for the Buffalo Study Area

INDUSTRY	Area	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Abrasives	Erie	no plants				
	Niagara	neg	2,100	neg	neg	neg
	Total	neg	2,100	neg	neg	neg
Carbon Products	Erie	no plants				
	Niagara	neg	620	neg	neg	neg
	Total	neg	620	neg	neg	neg
Cement	Erie	neg	470	neg	neg	neg
	Niagara	no plants				
	Total	neg	470	neg	neg	neg
Chemicals	Erie	310	1	neg	150	880
	Niagara	7,900	350	5,200	490	94
	Total	8,200	350	5,200	640	970
Gasoline Distribution	Erie	neg	neg	neg	6,200	neg
	Niagara	no plants				
	Total	neg	neg	neg	6,200	neg
Grains	Erie	neg	820	neg	neg	neg
	Niagara	neg	60	neg	neg	neg
	Total	neg	880	neg	neg	neg
Metals and Coke	Erie	20,000	25,000	240	140	neg
	Niagara	neg	15,000	1,100	neg	neg
	Total	20,000	40,000	1,300	140	neg
Refineries	Erie	8,100	220	~~10,000~~ 36,000	~~54,000~~ 15,000	130
	Niagara	no plants				
	Total	8,100	220	~~10,000~~ 36,000	54,000	130
Other	Erie	no plants considered				
	Niagara	neg	790	neg	1,900	8
	Total	neg	790	neg	1,900	8
Total	Erie	28,000	26,000	~~10,000~~ 36,000	~~60,000~~ 21,000	1,000
	Niagara	7,900	19,000	6,300	2,400	100
	Total	36,000	45,000	46,000	~~62,000~~ 23,000	1,100

neg-the amount of the pollutant is negligible.

Note that all numbers are presented to only two significant digits

Table 13 Emissions from the Chemical Industry of Niagara County

Compound	tons/yr emitted
Chlorine	1500
Hydrogen bromide	4
Hydrogen chloride (gas)	1500
Hydrogen	800
Hydrogen Sulfide	300

were obtained from the Oil and Gas Journal,[9] and data on the coke processing and cement mill were obtained from Keystone Coal Buyers Manual.[10] Additional information on the iron and steel industry was obtained from the Directory of Iron and Steel Works;[11] and data on the nitric acid plant were obtained from Atmosphere Emissions from Nitric Acid Manufacturing Processes[12] which contains a list of plants and capacities.

An estimate of the evaporative less of gasoline at the storage facilities was made. It was assumed that one half of the gasoline consumed in the state passed through the Buffalo area since the only other major source of gasoline would be from imports to the Hudson River area. There are only two refineries in New York and both are located in the Buffalo Study Area.

Solid Waste Disposal

Most of the pollutants in this category came from municipal incineration, however the quanties of pollutants are so small that they account for an insignificant portion of the total pollutants in the study area. The quantities of solid waste generated and disposal are presented in Table 14 and the resulting air pollutant emissions are presented in Table 15. These quantities are based on an assumed generation rate of 4 pounds per capita per day for Niagara county and a report of Day and Zimmermann, Inc. [13] for Erie county. The amount of solid waste incineraced and burned was obtained from the local inventories and it was assumed the remainder went to sanitary land fills.

Table 14 Solid Waste Disposal in the Buffalo Study Area

	Generated tons/yr	Open Burning tons/yr	Incineration		Land fill tons/yr
			Municipal tons/yr	on Site tons/yr	
Niagara County	171,000	4,200	61,000	5,200	100,600
Erie County	911,000	6,100	231,000	neg	673,900
Total	1,082,000	10,300	292,000	5,200	774,500

neg- the quantity of negligible.

Table 15 Emissions from Solid Waste Disposal (tons/yr) in the Buffalo Study Area

Source	Area	Sulfur Oxides	Particulate	Carbon Monoxide	Hydro-carbons	Nitrogen Oxides
Incineration	Erie	230	2,000	120	35	230
	Niagara	65	550	200	9	73
	Total	300	2,600	320	44	300
Open Burning	Erie	neg	49	260	15	34
	Niagara	neg	25	130	8	17
	Total	neg	74	390	23	51
Total	Erie	230	2,000	380	50	260
	Niagara	65	580	330	17	90
	Total	300	2,600	710	67	350

neg-negligible

Note that all numbers are presented to only two significant digits

EMISSIONS BY GRIDS

The emissions of the pollutants were apportioned on a grid basis and the results are presented in Table 16. The emission densities of the several pollutants were also calculated and these are presented graphically by ranges in Figure 5 through Figure 9.

All of the density maps show higher emissions rates in the industrial cities of Niagara Falls, and Buffalo. The densities are moderate in the suburban areas south of Buffalo and low in the rural portions of both counties, The hydrocarbons and carbon monoxide densities are moderate along Interstate 90 leading to Erie, Pa. and Cleveland, Ohio, and are high at the location of the refineries.

Table 16 Emissions by Grid for the Buffalo Study Area (tons/day)

Grid	Sulfur Oxides			Particulate			Carbon Monoxide		
	S	W	A	S	W	A	S	W	A
1	.07	.18	.21	.24	.25	.25	5.9	4.4	5.0
2	.13	.42	.27	.23	.28	.25	21.	16.	18.
3	.15	.34	.24	.31	.30	.30	17.	12.	14.
4	.01	.19	.10	.03	.05	.04	.97	.73	.82
5	.20	.56	.38	.27	.34	.30	16.	12.	13.
6	1.1	1.8	1.5	30.	30.	30.	19.	18.	19.
7	5.0	7.7	6.3	7.3	7.5	7.4	14.	10.	12.
8	.10	.25	.17	.24	.23	.23	27.	23.	24.
9	2.8	5.2	4.0	.36	.63	.50	8.4	6.4	7.2
10	78.	110.	93.	20.	24.	22.	28.	23.	25.
11	.16	.93	.53	.33	.43	.37	34.	29.	31.
12	15.	23.	20.	3.5	4.8	4.2	53.	40.	45.
13	.73	1.3	1.0	.58	.65	.60	27.	20.	23.
14	12.	20.	16.	8.6	12.	10.	9.3	7.4	8.1
15	1.1	2.2	1.7	.28	.40	.34	17.	13.	14.
16	79.	82.	79.	22.	24.	23.	55.	45.	45.
17	29.	45.	37.	12.	18.	15.	39.	30.	33.
18	9.7	15.	12.	4.1	6.1	5.1	49.	37.	41.
19	.29	1.1	.70	.53	.63	.56	5.6	4.3	4.8
20	290.	320.	300.	41.	52.	46.	80.	63.	70.
21	.40	2.3	1.3	.73	1.7	1.2	70.	53.	60.
22	9.7	15.	12.	4.5	6.4	5.4	44.	34.	38.
23	9.5	15.	12.	4.2	6.1	5.2	13.	10.	11.
24	13.	18.	17.	6.3	7.4	7.6	77.	58.	66.
25	20.	32.	26.	11.	16.	13.	91.	69.	78.
26	29.	44.	37.	12.	18.	15.	48.	37.	41.
27	19.	29.	24.	7.6	11.	9.5	16.	13.	14.
28	9.8	15.	13.	4.5	6.4	5.4	50.	38.	43.
29	22.	30.	27.	12.	15.	14.	19.	15.	16.
30*	Disclosure								
31	29.	43.	36.	12.	17.	14.	42.	32.	36.
32	.08	.42	.25	.16	.22	.19	13.	9.5	11.
33	no data								
34*	Disclosure								
35	9.6	15.	12.	4.0	5.9	5.0	34.	25.	29.
36	19.	28.	24.	7.4	11.	9.3	9.2	7.5	8.1
37	.02	.03	.02	.06	.06	.06	1.8	1.3	1.5
38	.18	.49	.34	.35	.34	.34	25.	19.	21.
39	.07	.10	.08	.15	.15	.15	9.3	6.9	7.9
40	9.5	15.	12.	3.8	5.7	4.7	7.4	5.9	6.5
41	19.	29.	24.	7.8	11.	9.6	40.	31.	34.

Table 16 Emissions by Grid for the Buffalo Study Area (tons/day) (con't)

Grid	Sulfur Oxides			Particulate			Carbon Monoxide		
	S	W	A	S	W	A	S	W	A
42	.25	.91	.57	.48	.53	.49	40.	30.	34.
43	.40	.40	.39	.88	.78	.81	40.	30.	34.
44	.29	.44	.35	.60	.55	.56	37.	27.	31.
45	.25	.58	.40	.58	.54	.54	24.	18.	20.
46	.11	.46	.28	.27	.27	.26	9.4	7.0	7.9
*30&34	300.	310.	300.	110.	120.	120.	140.	120.	130.
Erie	930.	1100.	1000.	290.	360.	330.	1100.	880.	920.
Niagara	120.	170.	150.	72.	82.	77.	300.	230.	260.
Total	1000.	1300.	1200.	360.	440.	410.	1400.	1100.	1200.

*Data for grids 30 and 34 were combined to prevent disclosure of the emissions from a single source.

Note that all numbers are presented to only two significant digits.

Table 16 Emissions by Grid for the Buffalo Study Area (tons/day) (con't)

Grid	Hydrocarbons			Nitrogen oxides		
	S	W	A	S	W	A
1	1.5	1.2	1.3	.44	.37	.44
2	3.1	2.3	2.6	1.4	1.2	1.2
3	2.6	2.0	2.3	1.3	1.1	1.2
4	.18	.14	.17	.10	.13	.11
5	2.4	1.8	2.0	1.5	1.6	1.5
6	.77	.61	.67	.80	1.1	.96
7	2.0	1.6	1.8	2.1	2.6	2.3
8	4.4	3.8	4.0	1.6	1.4	1.5
9	1.3	1.0	1.1	1.2	1.9	1.5
10	5.3	4.9	5.0	16.	24.	20.
11	5.4	4.6	5.6	2.1	2.1	2.1
12	12.	11.	11.	7.1	8.8	8.1
13	4.1	3.1	3.5	2.1	1.9	1.9
14	1.4	1.2	1.3	4.2	6.4	4.7
15	2.4	1.8	2.1	1.4	1.6	1.5
16	99.	97.	98.	14.	15.	15.
17	5.9	4.7	5.1	11.	15.	13.
18	6.8	5.3	5.9	5.7	6.8	6.1
19	7.5	5.6	6.3	3.3	3.2	3.2
20	13.	11.	11.	66.	75.	70.
21	9.9	7.6	8.5	4.5	6.0	5.1
22	6.4	5.0	5.5	5.7	7.0	6.3
23	2.1	1.8	1.9	3.8	5.3	4.5
24	11.	8.7	9.8	8.9	11.	10.
25	14.	11.	12.	12.	17.	14.
26	7.4	5.9	6.5	12.	16.	14.
27	2.5	2.1	2.3	6.7	10.	8.3
28	7.8	6.0	6.7	6.6	7.8	7.1
29	3.0	2.5	2.7	7.9	10.	9.6
30	* D i s c l o s u r e					
31	6.4	5.1	5.6	11.	15.	13.
32	1.9	1.4	1.6	.88	.96	.89
33	n o d a t a					
34	* D i s c l o s u r e					
35	4.9	3.8	4.2	4.9	6.0	5.4
36	1.5	1.4	1.4	6.2	8.9	7.5
37	.32	.24	.27	.19	.18	.18
38	3.8	2.8	3.2	1.8	1.6	1.6
39	1.4	1.1	1.2	.69	.68	.67
40	1.2	.99	1.1	3.3	5.0	4.1
41	5.9	4.6	5.1	5.9	4.6	5.1

Table 16 Emissions by Grid for the Buffalo Study Area (tons/day) (con't)

Grid	Hydrocarbons			Nitrogen oxides		
	S	W	A	S	W	A
42	5.8	4.3	4.9	2.7	2.6	2.6
43	6.6	5.0	5.6	3.5	3.0	3.1
44	5.7	4.2	4.8	2.8	2.4	2.5
45	4.0	3.0	3.4	2.2	1.9	2.0
46	1.7	1.3	1.4	.93	.91	.89
*30&34	110.	100.	100.	51.	57.	54.
Erie	360.	310.	330.	270.	300.	270.
Niagara	49.	41.	44.	43.	56.	49.
Total	410.	350.	380.	310.	350.	320.

* Data for grids 30 and 34 were combined to prevent disclosure of the emissions from a single source.

Note that all numbers are presented to only two significant digits

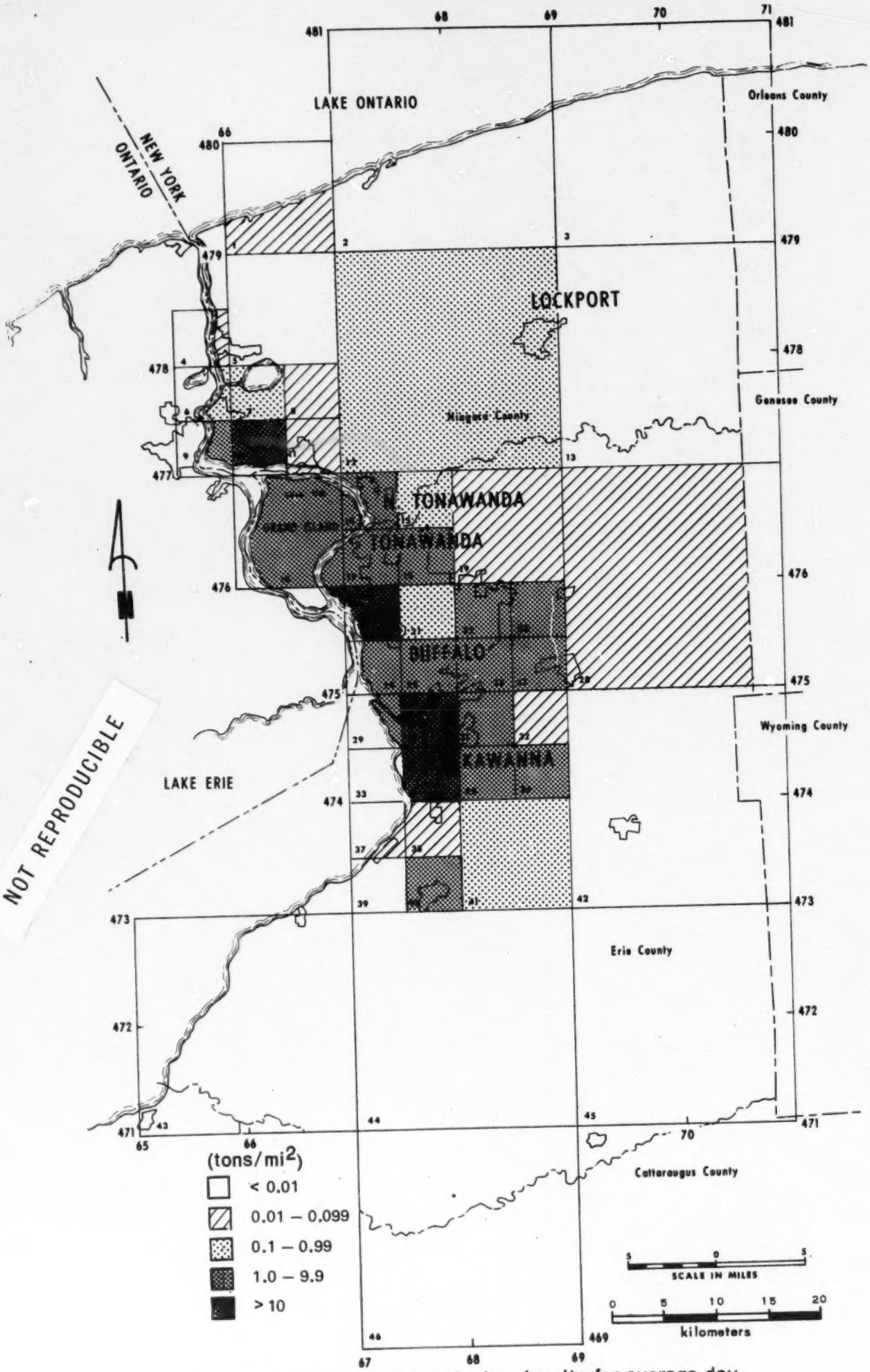

Figure 5. Sulfur oxides emission density for average day.

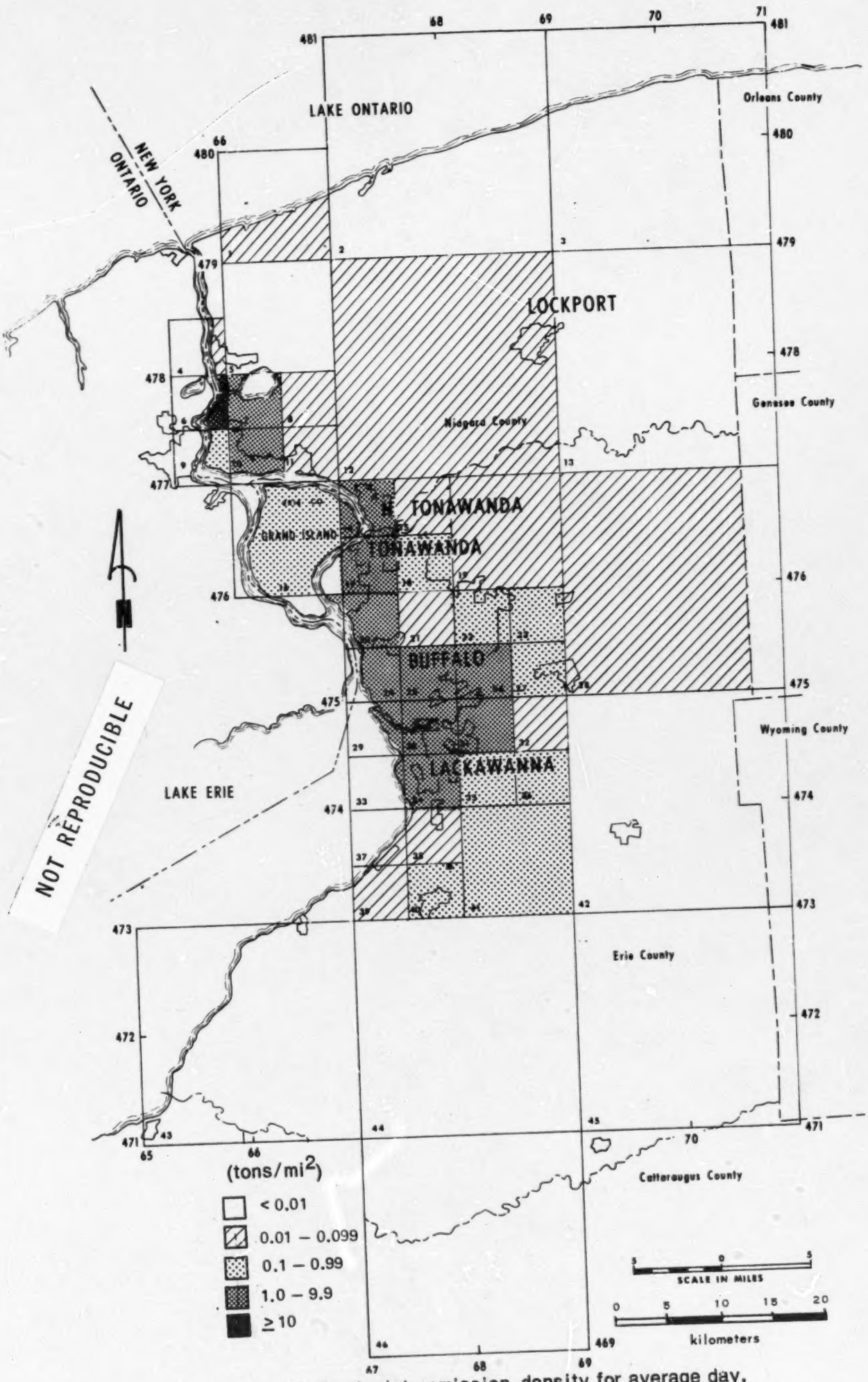

Figure 6. Particulate emission density for average day.

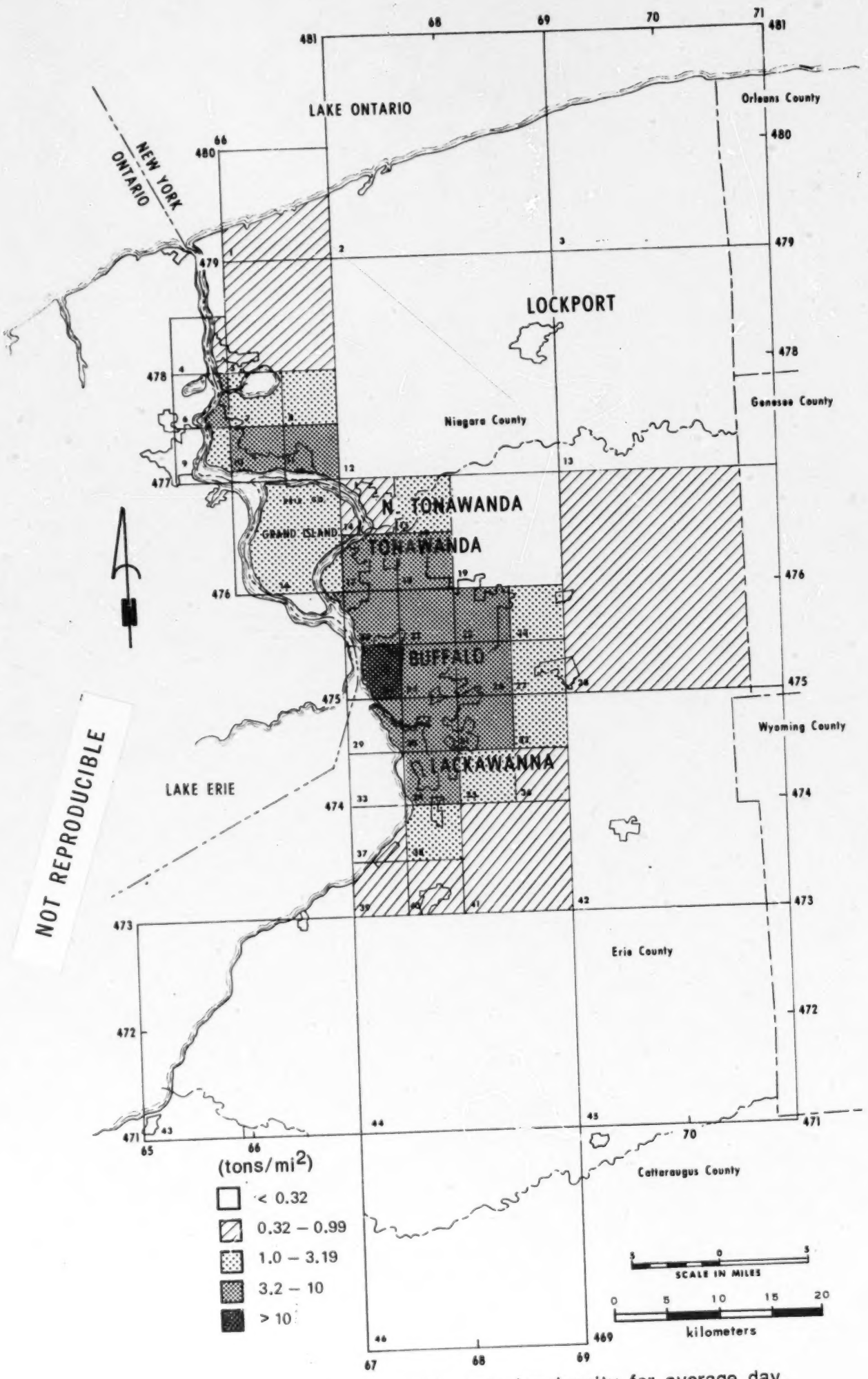

Figure 7. Carbon monoxide emission density for average day.

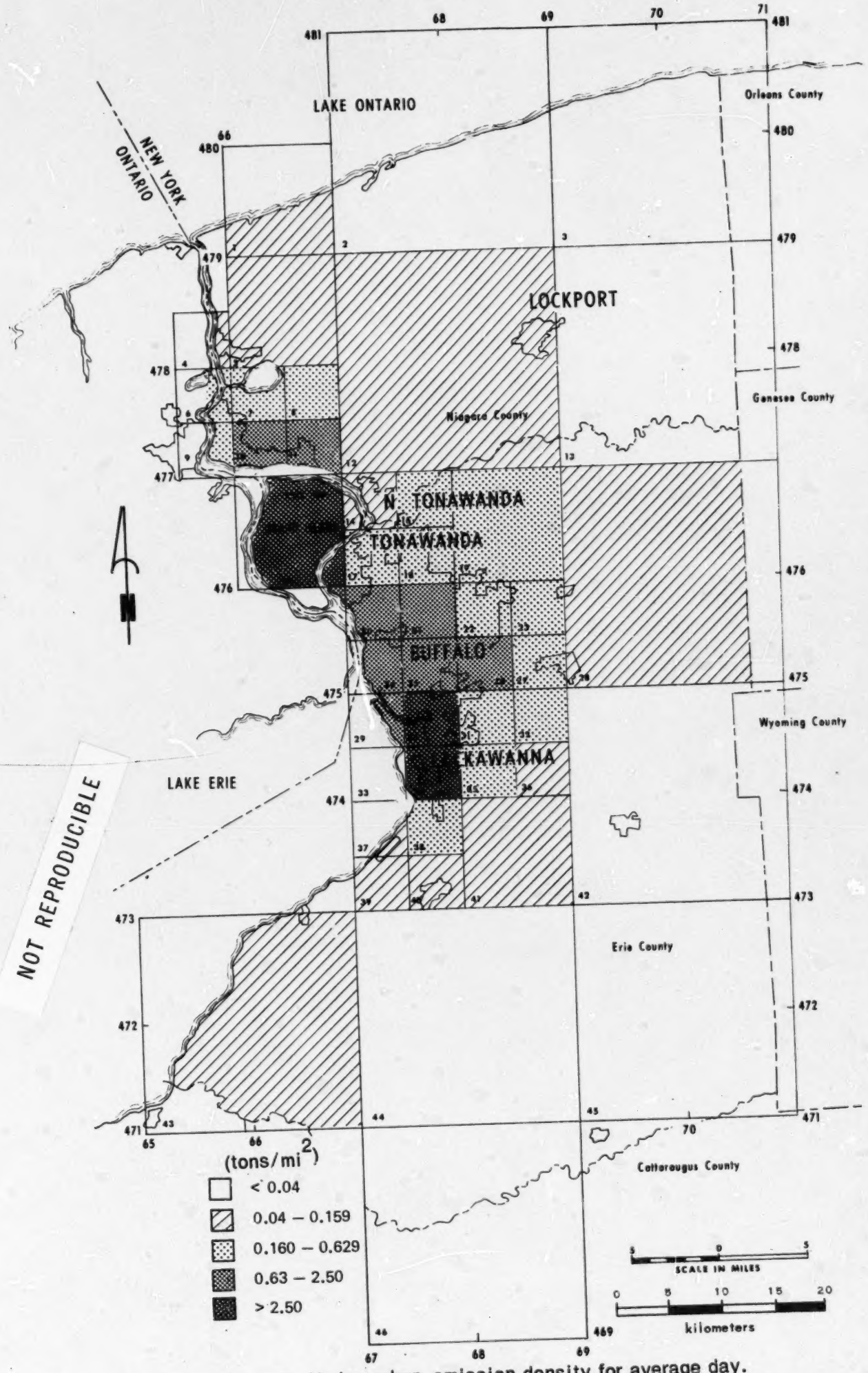

Figure 8. Hydrocarbon emission density for average day.

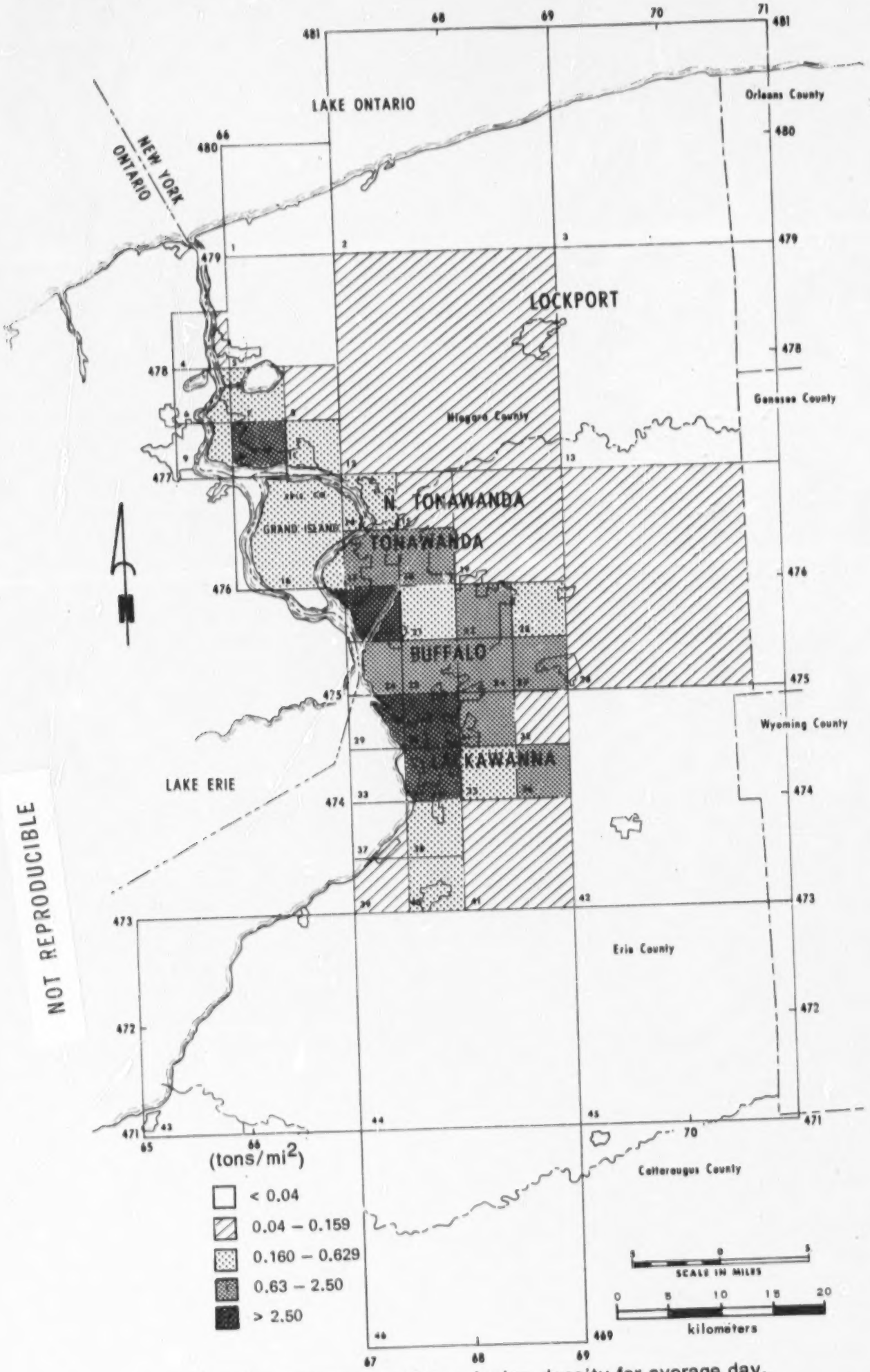

Figure 9. Nitrogen oxides emission density for average day.

NOT REPRODUCIBLE

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APPENDIX

METHOD FOR CALCULATING SUMMER, WINTER AND ANNUAL AVERAGE EMISSIONS FOR FUEL CONSUMPTION IN STATIONARY SOURCES

YEARLY AVERAGE (A)

$$A = \frac{\text{Fuel Consumed} \times \text{Emission Factor (E.F.)}}{\text{Days of Operation}}$$

e.g. A plant consumed 100,000 tons of coal in 1967 while operating 365 days. The total degree days for the area was 4,800 and 2,800 for the three winter months. The plant was estimated to use 15 percent of the fuel for space heating and 85 percent for process heating. From this information, the annual average emission for carbon monoxide would be the following:

$$A = \frac{100{,}000 \text{ Tons/year} \times 3 \text{ lbs. CO/Ton coal}}{365 \text{ Days/year} \times 2{,}000 \text{ lb./Ton}}$$

$$A = 0.41 \text{ Ton/Day}$$

WINTER AVERAGE (W)

$$W = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Winter Operation}} \times \frac{\text{Winter Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$W = \left[\frac{100{,}000 \times 2{,}800}{90 \times 4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$W = 0.49 \text{ Ton/Day}$$

SUMMER AVERAGE (S)

$$S = \frac{\text{Fuel Consumed} \times \text{E.F.}}{\text{Days of Summer Operation}} \times \frac{\text{Summer Degree Days}}{\text{Total Degree Days}} \times \text{\% Fuel Used for space heating}$$

$$+ \frac{\text{Fuel Consumed} \times \text{E.F.}}{365} \times \text{\% Fuel used for process heating}$$

$$S = \left[\frac{100{,}000}{90} \times \frac{0}{4{,}800} \times 0.15 + \frac{100{,}000}{365} \times 0.85\right] \frac{3}{2{,}000}$$

$$S = 0.35 \text{ Ton/Day}$$